National Bureau of Standards

TECHNICAL NEWS BULLETIN

VOLUME 35 APRIL 1951 NUMBER 4

Mobile Ionospheric Station

The propagation of radio waves over long distances depends on their reflections from the ionosphere, a series of electrically conducting layers in the earth's atmosphere. Because these layers are continuously changing, knowledge of their characteristics is necessary for regular and reliable radio comunications. The Central Radio Propagation Laboratory of the National Bureau of Standards collects and analyzes ionospheric data from stations all over the world. From the data, the Bureau makes and publishes predictions of usable frequencies for communications between any two places at any hour.

In an effort to obtain more comprehensive data on the ionosphere, the Bureau has now incorporated a mobile ionospheric research unit into the existing chain of 60 world-wide ionosphere stations—approximately one-fourth of which are maintained by the Bureau. With this new unit, ionospheric soundings will be made from points midway between two permanent transmitting-receiving stations. This information will be used in studies of ionospheric effects on radio waves directly above the mobile transmitter-receiver; and it will also aid in analyzing the behavior of radio waves propagated from transmitters to distant receivers.

The NBS mobile unit might more properly be called an ionosphere research caravan because it is made up of two prime movers and two trailers. The equipment includes two gasoline-powered motor-generators that will provide 10,000 watts each of electrical power for the transmitting, receiving, and recording components in the event commercial power is unavailable. One of the trailers has been converted into living quarters for the two-man operating crew for use in regions where living accommodations cannot be obtained.

The caravan's first recording stop, 30 miles east of Cincinnati, Ohio, is a point midway between the Bureau's transmitting station at Sterling, Va., and a leased transmitting station operated by Washington University, St. Louis, Mo. The project, known as the "St. Louis Experiment", is expected to continue for 3 or 4 months. When the experiment is completed, the unit will be moved to another center-point site. Within a few years and after a number of midpoint locations, the Bureau expects to have sufficient information about the ionospheric radio propagation to map accurately the paths of radio waves across the country and into other parts of the world.

During the past 20 years the technique of vertical-incidence ionosphere soundings by the use of pulse transmitters scanning over a wide frequency range has been adopted internationally for recording the virtual height and degree of ionization for each of the ionosphere layers. Although vertical-incidence reflection principles are basic to the understanding of radio propagation, they are rarely encountered in practical radio communication. The wave received at a distance from the transmitter impinges on the ionosphere obliquely in its journey from the transmitter to the receiver. However, theory indicates that much information about oblique incidence propagation can be inferred from data obtained at vertical incidence. The St. Louis experiment and all of those to follow are designed to

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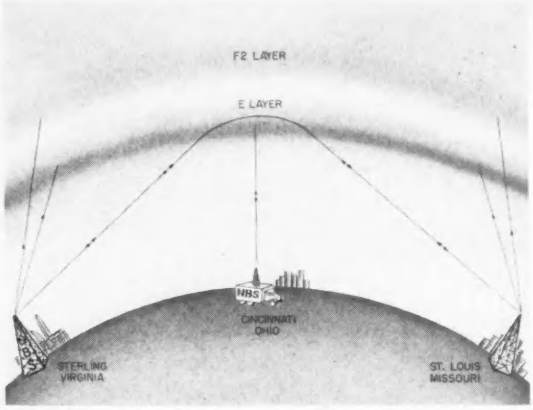

The NBS "St. Louis Experiment" will investigate the wave propagation path of signals simultaneously transmitted by stations in Sterling, Va., and St. Louis, Mo. The mobile station will evaluate ionospheric effects at the midpoint of the path. High-angle radiation will penetrate the layers and will not return, while the signals radiated at low angles will be reflected from the layers.

record simultaneously both vertical and oblique incidence data, and from an analysis of the information the relation between oblique and vertical incidence reflectors will be more exactly deduced.

In the St. Louis experiment, the Sterling and St. Louis stations will simultaneously transmit pulses of radio energy directed to strike the ionosphere obliquely. The radio waves will be propagated in west and east directions, respectively, and each station will receive the other's signals. Because the pulses must pass all the way up to the ionosphere at the midpoint of the path and then be reflected down again, the travel time will be greater than if the signals were traveling directly along the earth's surface. From the time delays involved, the time of ionospheric travel between the stations will be obtained and the heights of reflection calculated. During the transmission, the radio frequencies used at both ends of the paths will be slowly but simultaneously varied. At the higher frequencies the time delays will be greater, because these waves travel to greater altitudes before they are reflected. Meanwhile the mobile station located at the critical point of the propagation path will transmit signals vertically upward and receive its own echoes. By recording the heights and degree of ionization of the several layers, the heights at which, according to simple theory, the oblique incidence signals should be reflected, can be calculated.

TECHNICAL NEWS BULLETIN

U. S. Department of Commerce

Charles Sawyer, *Secretary*

National Bureau of Standards
E. U. Condon, *Director*

APRIL 1951 **Issued Monthly** **Vol. 35, No. 4**

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Subscription price, domestic, $1.00 a year; foreign, $1.35; single copy, 10 cents. The printing of this publication has been approved by the Director of the Bureau of the Budget, February 3, 1950.

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The National Bureau of Standards mobile ionospheric station has recently been incorporated into the Bureau's world-wide chain of ionosphere stations. The trailer (left) houses the transmitting, receiving, and recording equipment. The truck contains living quarters for the two-man crew. Two gasoline-powered generators each provide 10 kilowatts of stand-by power.

Transmitting-receiving-recording equipment of the mobile ionosphere station. The model C–3 automatic ionosphere recorder (left), developed by the Bureau's Central Radio Propagation Laboratory, transmits 20 kilowatts and is capable of scanning a frequency range of 1 to 25 megacycles in 7.5 seconds.

All three transmitting-receiving stations will use the model C–3 automatic ionosphere recorder developed by the Bureau. Its transmitted power is 20 kilowatts, and it is capable of scanning a frequency range of 1 to 25 megacycles in a time interval as small as 7.5 seconds. Signals will be transmitted, received, and recorded on film strips at a 24-hour per day basis.

The St. Louis experiment involves comparatively short distances. However, it is known that the discrepancies between theory and practice increase in magnitude as the distance between transmitter and receiver becomes greater. To investigate this effect, the mobile unit will be placed at the midpoint of much more widely spaced permanent installations. The next stop may be between the Sterling station and one in the Hawaiian Islands, Alaska, San Francisco, Puerto Rico, or Panama. Before the program is completed, the mobile unit will have been placed at the midpoint of the path to most of the Bureau's ionosphere stations in the western hemisphere.

The Bureau will analyze the film-strip records from each tri-station experiment. The analysis will shed more light on the causes of fading and explain the complete loss of a signal between the transmitter and the receiver. Thus, at the end of this unusual series of experiments, the Bureau will be in a position to supply all the users of long-range communications with more accurate information for selecting the proper frequency to transmit intelligence over a certain path at any particular time of the day and year.

Controlled Humidity for Research

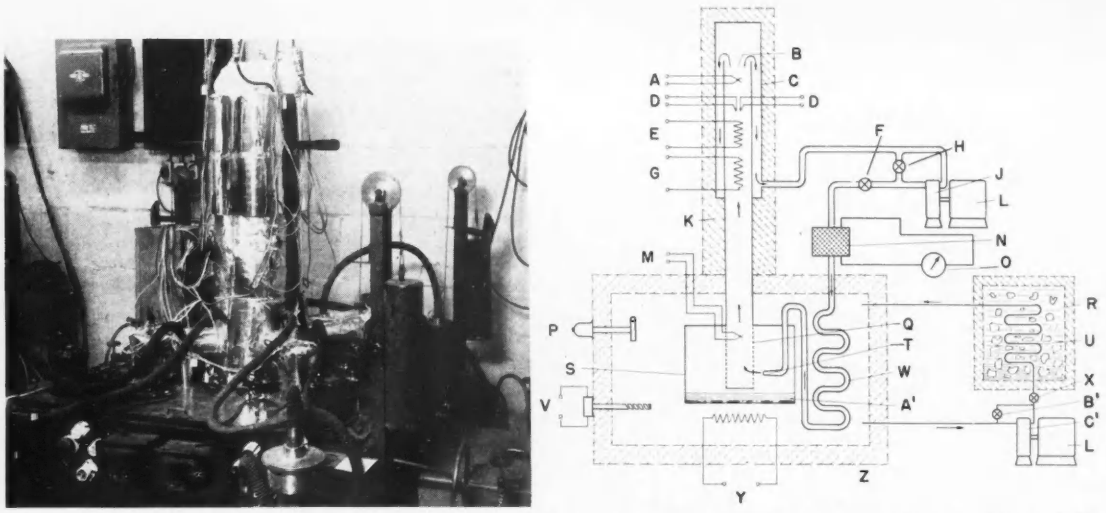
Convenient means of producing and maintaining atmospheres of known relative humidity at any of the temperatures encountered in a radiosonde flight have been developed at the National Bureau of Standards. A recirculating type of apparatus was devised for calibration and research purposes by A. Wexler and associates of the Bureau's mechanical instruments laboratory under the sponsorship of the Bureau of Ships, Department of the Navy.

The need for such a device results from the use of the electric hygrometer for sensing water vapor content of the air during a meteorological sounding of the upper atmosphere by means of the radiosonde. During a flight, the hygrometer may be subjected to a wide range of temperatures and humidities, as well as air flows, corresponding to ballon ascent rates of 1,000 feet per minute or more. The new equipment was designed primarily for operation at temperatures above freezing, but is equally useful at temperatures down to $-40°$ C. Provision was made for obtaining discrete changes in humidity and temperature and for maintaining given air speeds up to 1,500 feet per minute. The recirculating apparatus supplements equipment previously developed at the Bureau for use at temperatures below freezing.

A known relative humidity is produced by saturating a stream of air with water vapor at a given temperature and then raising the temperature of the air to a specified higher value. The relative humidity, at the higher temperature, is the ratio of the saturation pressure of water vapor at the lower temperature to the saturation pressure of water vapor at the elevated temperature. A gas pump circulates air from a saturator into a test-chamber and then back into the saturator. Complete saturation is achieved, simply and efficiently, by recirculating the air over water or ice in the saturator, in a closed system.

The temperature of the saturator is maintained constant by a thermostated liquid bath, while that of the test-chamber is controlled by means of a heater in the air stream. This is possible because the air from the saturator must necessarily be brought to a higher temperature, and hence the only requirement for achieving any desired test-chamber temperature is the introduction of the requisite amount of heat into the air stream.

The important features of the saturator are its simplicity of design, its adaptability for temperatures below as well as above the freezing point of water, and its effective saturation at both high and low flows. These are achieved in large measure by imparting a centrifugal action to the entrant air stream. The saturator is a cylindrical chamber containing distilled water to a convenient depth. Air is discharged through a nozzle into the chamber above the water surface and tangential to the vertical walls and then exhausted through a central port in the top. The centrifugal action creates a whirlpool which greatly increases the liquid surface and thoroughly mixes water vapor with



The new NBS recirculating apparatus for testing electric hygrometers at temperatures from +20° to −40° C (left). The components and principle of its operation are shown in the schematic diagram (right).

(A) Test-chamber themocouple; (B) test chambers; (D) thermistor; (G) gross heater; (J) gas pump; (L) motor; (M) saturator themocouple; (N) flow meter; (O) differential pressure gage; (Q) screen; (R) dry-ice bath; (S) saturator; (U) coil (liquid); (W) coil (air); (Y) bath heater; (Z) themostatted Varsol bath; (A′) water; (C′) circulating pump.

the air. Spray and liquid droplets are forced to the walls by centrifugal force, which results in little tendency for liquid water to emerge through the exit port except at low flows. Under these conditions, a multilayer fine wire screen baffle at the exit traps water and prevents it from passing out of the saturator. As air does not bubble through water but only passes over its exposed surface, the water may be frozen without impairing the functioning of the saturator.

Rapid and discrete changes in relative humidity are achieved by utilizing four independent but identical recirculating systems arranged so that their test chambers may be interchanged easily and quickly. Thus, if a different temperature is maintained in each of the four saturators, and if the same temperature is maintained in each test chamber, the relative humidity in each test chamber is different. By interchanging the test chambers, the relative humidities therein undergo discrete changes as each test chamber communicates with a different saturator.

The interchange of test chambers is effected by a pneumatic switch consisting of two ground and lapped plates to which are attached air lines leading from the saturators to the test chambers. A quarter turn of the top plate with respect to the bottom plate advances each test chamber to a new position and connects each test chamber with a different saturator. The relative humidity can be changed at a speed of about 1 to 2 seconds and depends primarily on the speed with which the switch can be rotated.

The gravimetric method of moisture determination was employed to check the accuracy of the apparatus. Measurements of the relative humidity produced in the test chamber were made over a wide range of test-chamber temperatures, relative humidities, and air flows. The results reveal an average difference in percentage of relative humidity of ± 1.2 percent between the relative humidity measured by the two techniques. As an additional check, a thermocouple psychrometer was employed to measure the actual relative humidity in the test chamber. These results show an average difference of ±0.9 per cent between the psychrometric relative humidity measurements and those of the apparatus.

For further technical details, see Recirculating apparatus for testing hygrometers, *by Arnold Wexler, J. Research NBS* **45,** *357 (1950) RP2154; and* Divided-flow, low-temperature humidity test apparatus, *by Arnold Wexler, J. Research NBS* **40,** *479 (1948) RP1897.*

A Stable Electronic Voltage Regulator

A new electronic direct-current voltage regulator, having an over-all stability of 0.01 percent, has been developed by P. G. Sulzer of this Bureau. The simplicity of the circuit makes it particularly useful for incorporation into the design of amplifiers and other electronic devices requiring compensation for changes in power-supply input voltage and load current. This circuit delivers currents up to 80 milliamperes at 250 volts; by inserting additional voltage-control tubes the range may be further extended with no appreciable change in regulation.

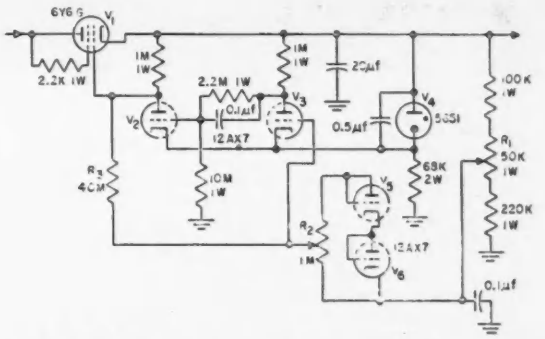
The regulator consists of a voltage-control tube, a direct-current amplifier, a stable voltage standard, and a means for comparing the controlled voltage with the

ndard voltage. Comparison occurs in the grid-thode circuit of a high-gain voltage amplifier. By scading amplifiers the gain can be increased and gulation appreciably improved. Normally in regulators of this type, the over-all gain is seriously decreased by cathode degeneration. The Bureau's improved circuit, however, compensates for this degeneration by connecting the amplifier cathodes so that they see a low impedance through a 5651 glow-tube voltage standard. The control grid of the voltage amplifier is connected to the voltage divider across the output of the regulator; thus, output variations are applied to the cathodes of the amplifiers.

Previously it had been found that heater-voltage variations due to varying line voltages were reflected in the output of voltage regulators. However, in the new device almost complete compensation is obtained over the normal range of heater-voltage variation by inserting a pair of diodes in series with the control grid of the second voltage amplifier, and operating the diodes and amplifiers from a common heater supply.

Improvement in the performance of the circuit may be achieved by increasing the voltage-amplifier gain through regeneration. Proper resistance coupling between the plate of the second voltage amplifier and the grid of the first will effectively make the amplifier gain infinite, resulting in perfect regulation.

Measurements have shown the output voltage to be constant within 0.02 volt for a 10-percent variation in line voltage at load currents from 0 to 80 milliamperes. In stability tests the output voltage was constant within 0.025 volt (with a fixed load) over a period of 1 day. At all frequencies below 200 kilocycles, the output impedance was less than 0.02 ohm.



Schematic diagram of a stable electronic voltage regulator. This circuit gives a stabilized direct-current output of 250 volts at 80 milliamperes. A cascaded amplifier is used to increase the gain and improve the regulation. Two series diodes compensate for heater-voltage variations.

For further technical details, see Stable electronic voltage regulator, *by Peter G. Sulzer, Electronics* **23,** *164 (Dec. 1950).*

Automatic Device Computes Timepiece Correction

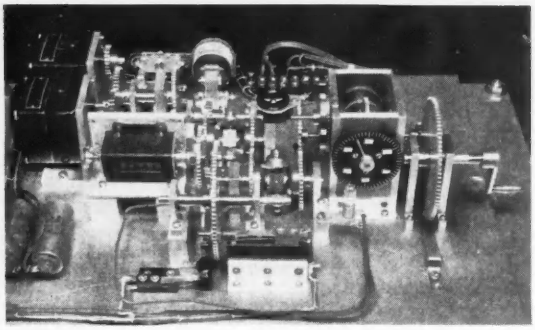
An automatic correction-computing chronograph recently developed by H. A. Bowman and F. E. Jones of the Bureau makes possible large savings in the time required to test clocks, watches, chronometers, and other timepieces. A differential gear system is used to subtract indicated time from standard time, and the operator merely records the correction shown on the dials of a revolution counter. Thus the opportunity for human error is reduced to a minimum.

In precision tests on timepiece performance, the quantity most often determined is "correction", defined as the difference between true standard time and the time indicated by the device under test. After the correction has been found, it is used in other computations to provide information on performance characteristics. Thus, determinations of temperature and position effects, as well as magnetic and isochronal characteristics, all basically depend upon the accuracy with which correction is obtained.

While several instruments for the rapid determination of rate are commercially available, these devices are not designed for precise evaluation of timepiece performance. In the past, accurate determination of correction has been accomplished by the use of a recording chronograph adjusted to standard time. The true standard time corresponding to any indicated time of observation was obtained by measuring distance along the chronograph sheet with a special scale. Numerous small time-consuming operations were involved, such as insertion of the record sheet in the chronograph, adjusting the chronograph with standard time, reading the standard time of observation from the chronograph sheet, recording this reading, and subtracting the indicated time of observation from the standard time. As a result, where large numbers of watches were under test simultaneously, an excessive amount of time was spent in determination of correction. The Bureau therefore undertook to develop an automatic instrument that would eliminate the waste of time and opportunity for error inherent in the older method.

In the Bureau's device, standard time is introduced into one of the wheels of the differential gear by a 60-rpm synchronous motor operated on a quartz-crystal-controlled frequency accurate to one part in 50 million. The time indicated by the watch under test is introduced into the second wheel of the differential gear, causing the differential shaft to take a position that is a function of the difference between indicated time and standard time. Thus a revolution counter operated by the differential shaft indicates correction.

Actually, the gear wheel through which indicated time is introduced is not rotated continuously as it is not ordinarily feasible to connect mechanically the watch under test with the differential gear system. Instead, the wheel is rotated manually through a given number of revolutions that are indicated on a dial



In the Bureau's automatic correction-computing chronograph, a standard 60-cycle current is applied to the synchronous motor (upper left), which rotates one wheel of a differential gear. A revolution counter on the differential shaft then indicates the difference between the standard time supplied by the motor and "watch time," which is introduced in the differential system by means of the crank (right).

calibrated in minutes and seconds. The wheel is then clamped, and correction is read from the revolution counter at the instant the test watch shows this predetermined time.

In order to read the rapidly moving revolution counter, the observer stops the counter by depressing a telegraph key at the instant the watch is seen to have the desired reading. To avoid loss of time in the standard gear wheel, a memory device is provided that "remembers" how long the operator has the differential gear shaft clamped. This device takes the form of a second differential gear, which absorbs and stores the motion of the synchronous motor on a slowly moving memory wheel. When the operator has finished recording the reading of the revolution counter, the memory wheel is returned to its initial position. In resetting the memory wheel, a number of rotations proportional to the time previously lost is automatically cranked into the revolution counter. The telegraph key, controlling a relay and solenoid, is used to clamp the differential gear shaft and at the same time to release the second differential system, which actuates the memory wheel.

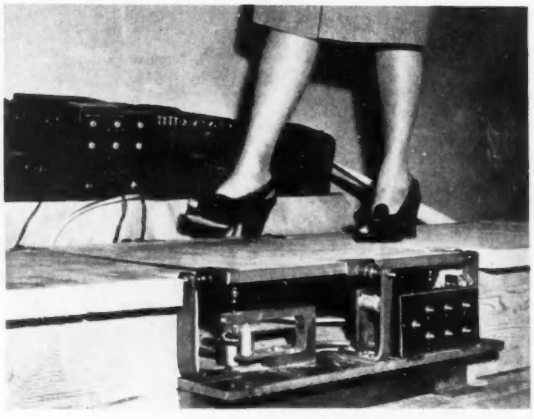
Electronic Stepmeter Reveals Mechanics of Walking

The elimination of the hazards imposed by slippery walkway surfaces—responsible each year for a large number of serious injuries and accidental deaths—is the principal objective of a research project at the National Bureau of Standards. To obtain basic quantitative data on some of the factors involved in the slipperiness of walkways, the Bureau has devised an electronic stepmeter that measures the three components of force produced between the foot and the floor in normal walking. Data thus provided on the mechanics of walking should materially aid in the development of a suitable instrument and method for measuring the slipperiness of walkway surfaces.

Human locomotion is accomplished by virtue of the force exerted by the leg on a walkway surface. Gravity and the friction between the two contact surfaces are important factors. Information in the literature that applies directly to the problem of analyzing the interaction between walkway and footwear surfaces and establishing of the range of conditions likely to be encountered in walking is meager.

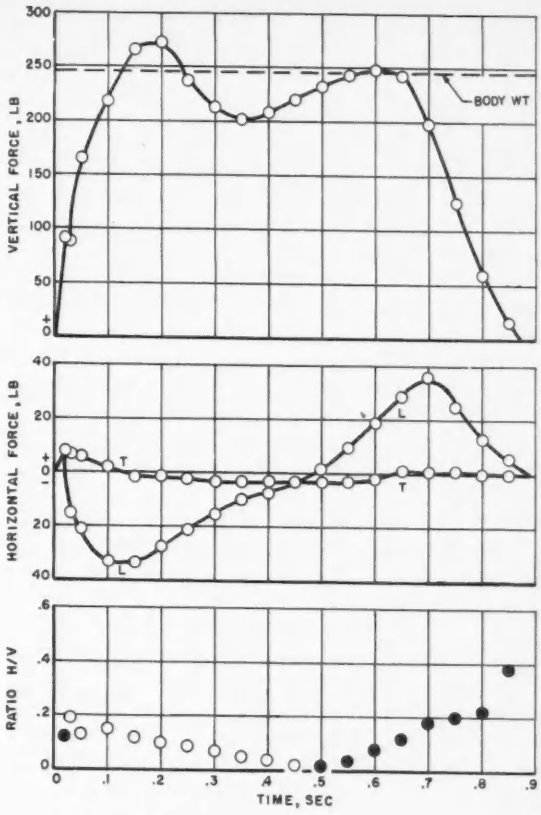
Under the direction of Percy A. Sigler of the Bureau's Building Technology Division, the project has involved several phases of investigations. These include a study of published pictures of persons at various stages of locomotion; the production and study of slow-motion pictures of people walking; an investigation of the contour of the rear portion of worn shoe heels; and the quantitative determination of vertical and horizontal components of the force exerted by the leg on a walkway surface during progression by means of an electro-mechanical force plate.

The electronic stepmeter, developed by W. E. Williams of the NBS staff, consists primarily of a 2-foot square platform mounted on ball bearings attached to four -shaped springs. The four sides of the platform bear against ball bearings attached to -shaped springs that are kept under slight tension so that all will follow the horizontal motion of the platform. Electromechanical pick-ups, an adaptation of the electronic mutual-inductance micrometer previously developed by M. L. Greenough at the Bureau, are mounted adjacent to the appropriate springs. Deflections of the springs due to forces exerted against them produce output volt-



The electronic stepmeter measures the vertical and horizontal components of the forces exerted by the leg on a walkway surface during a step. Deflections of the springs at the four corners of the platform produce output voltages in the electro-mechanical pick-ups proportional to the forces involved. The output voltages are amplified and recorded with respect to time by an oscillograph.

Graphs of the vertical, longitudinal (L), and transverse (T) forces recorded during the step of a man 6 feet 4 inches tall, weighing 247 pounds, and wearing shoes with large rubber lugs on the heels and soles. The ratio H/V defines the minimum coefficient of friction necessary to prevent the foot from slipping at the particular stage of the step involved. The open circles represent a potential slip in the forward direction, the closed circles a potential slip in the backward direction.



ages in the pick-ups proportional to the forces in each of three directions—vertical, longitudinal, and transverse. Walkways on a level with the platform of the stepmeter are used so that walking on a level surface can be simulated. The output voltages are amplified and are recorded with respect to time by an oscillograph.

Oscillographic recordings of the vertical and horizontal components of the force exerted by the leg on the platform of the stepmeter during a step have been analyzed for seven men and five women. Curves for the vertical forces show two maxima during each step, usually greater than body weight, and a minimum, between the two maxima, usually less than body weight. The two maxima occur when the body is being accelerated upward.

Curves for the horizontal forces in the longitudinal direction frequently show a slight backward thrust when the foot first contacts the platform, indicating that the body is being accelerated forward. This backward thrust is of very short duration and occurs at about the same time the curve for the vertical force shows a sudden deflection or reversal in direction. The conditions under which the measurements were made may be largely responsible for this initial backward thrust, which may not be typical for a step after normal gait is established. The third step taken by a subject from a stationary stance was the one recorded, and thus the average horizontal velocity of the body was probably being increased in order to establish normal gait. Also, a subject naturally considers the platform of the stepmeter as a target to be hit by the foot, so that the initial impact of the foot on the platform may not be indicative of automatic gait during which most slips and falls occur.

The longitudinal forces (L) reach a maximum in the forward direction shortly after the heel contacts the platform, thus retarding forward movement of the body. They reach a maximum in the backward direction as the ball of the foot prepares to leave the platform, thus accelerating the body in the direction of progression.

The transverse forces (T) were relatively small. For the most part, their direction is outward from the body and depends upon which leg is involved. The transverse forces, however, would likely be materially increased when the direction of progress is abruptly changed.

The horizontal forces are the ones that must be counteracted by friction in order to avoid slipping. The ratio between the resultant of the horizontal forces and the corresponding vertical force represents the minimum coefficient of friction necessary to prevent the foot from slipping on a walkway surface at the particular stage of the step involved.

The general shape of the curves for all of the subjects was surprisingly similar. The principal difference in the oscillographic recordings was in the magnitude of the maximum values for both the vertical and longitudinal forces. The weights of the 12 subjects ranged from 107 to 247 pounds, their heights from 5 feet 2 inches to 6 feet 4 inches, and their ages from 27 to 60 years. Their footwear included rubber and leather heels and soles, and, for the women, low, medium, and high heels. These differences, however, did not materially change the ratios between the horizontal and vertical forces for corresponding stages of the step.

In general, the results showed that during the retarding phase of a step, a minimum coefficient of friction of around 0.2 is essential if slipping is to be avoided. When walking is entirely automatic and subject to sudden changes in velocity and direction, a higher coefficient would likely be necessary to prevent slipping. Coefficients of friction of less than 0.2 are obtained with the Bureau's dynamic pendulum-impact type slipperiness tester [1] on many smooth-faced floors when wet.

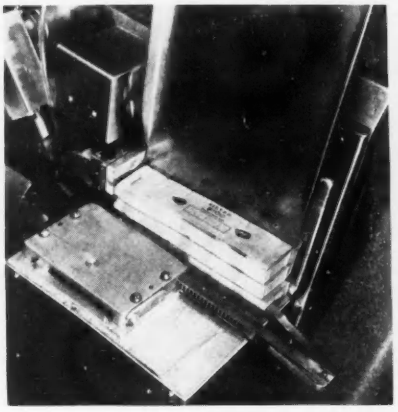
[1] *See* Measurement of the slipperiness of walkway surfaces, *NBS Tech. News Bulletin* **31**, 40 (*April 1947*).

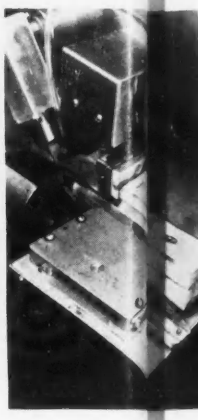
Electronic Coun

A fully automatic electronic machine for counting worn-out paper money has been designed and developed by H. M. Joseph and Carroll Stansbury of the National Bureau of Standards. Sponsored by the Department of the Treasury, the NBS Electronic Currency Counter—capable of counting 30,000 bills per hour—will replace the present hand-count system at a saving of about a quarter of a million dollars a year to the Department. A total of 25 currency counters, designed, constructed, and proof-tested at the National Bureau of Standards, will soon be placed in service by the Treasury's Redeemed Currency Unit, which has the responsibility of accounting for the unfit notes removed from circulation by Federal Reserve Banks throughout the Nation.

Replacement of the worn-out bank notes by new ones involves the redemption of some 8 tons of currency daily. Although new paper money has been machine-counted for many years, mechanical handling of worn-out notes has, until now, been a difficult problem. The NBS Electronic Currency Counter is designed to count packets of 100 notes and to reject automatically those with more or less than 100. An electromechanical device, the machine consists essentially of a trough to receive the packets of money; a mechanism for inserting and grasping each packet in a spindle; a friction band and air jet that separates the notes in regular intervals; and a binary counting circuit actuated by pulses from a photocell light-beam system.

Money returned to the Treasury is in the form of packets of 100 notes cut longitudinally into half-notes. The bulk of the returned money—about 5 million dollars worth—consists of 1-dollar bills, constituting about 80 percent of all the U. S. currency received for redemption. The bills are limp, wrinkled, and difficult to handle; occasionally single torn notes are taped together. These and similar problems have meant that the condition of the returned money is variable, and tedious counting by hand has been necessary. The need for an effective mechanical means that would combine both rapid counting and accuracy prompted the Treasury Department to initiate, in 1947, a new developmental program directed toward machine counting. The Bureau was requested to assume the technical direction of this project.





During operation of the electronic paper money counter de by th (left) from feeder trough to the spindle (center). As idle r notes, flipping them so that a phototube light beam is inter The

Light-Beam Counting

A high degree of reliability is attained in the NBS Electronic Currency Counter through the use of the light-beam counting technique. In this method, the cut packet of half-notes is clamped in and wrapped around a spindle to obtain the necessary separation between the ends of the sheets. The free ends of the sheets are then released as they rotate on the spindle, and a jet of air fans each sheet out into the light-beam of a phototube. The regular interruption of the photoelectric beam by each sheet causes current variations in the phototube circuit which, in turn, are formed into suitably shaped pulses and applied to an electronic counter. Experimental use of the light-beam method in counting several thousand packets showed erroneous overcounts in less than 1 percent of the packets counted. These results are well within the limitations set by the Treasury Department.

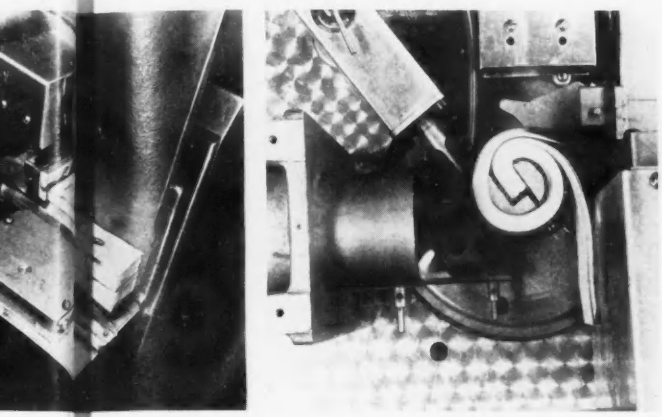
When the technique is applied to the worn half-notes, certain critical design requirements must be observed. The light beam must have an appreciable cross section (approximately $\frac{1}{8}$ by $\frac{1}{4}$ inch) to avoid false operation by stray bits of paper and must be placed at such an angle as to be reliably interrupted only by single sheets. To avoid turbulence and whipping of the sheets, the air jet must be placed tangentially and as close to the contour surface as practicable. The friction band must have sufficient freedom, but at the same time it must have absolute control of the free ends so that only single sheets are released during the counting procedure. Experiment has shown that the jaws of the spindle must be shaped so that the outer contour of the wrapped half-notes is nearly circular.

Description of Machine

For flexibility, a separate, completely self-contained cabinet, mounted on casters, is used for each counting head. Automatic feeding and removal of the packets to and from the counting head, an input magazine that can be periodically replenished with packets to be counted, and "correct" and "reject" outlet chutes, through which counted packets emerge, are provided. When notes snarl around the counting head, which occasionally proves to be unavoidable, the machine stops, undamaged, until it is untangled. For ease of maintenance, the counter is composed of readily replaceable subassemblies that are completely interchangeable with duplicates.

The input magazine is an inclined trough. At the

Counting of Paper Money



Counter developed by the National Bureau of Standards, the half-notes are pushed (left). As spindle rotates (right), a jet of air blows past the ends of the notes and interrupts the light beam. The count is recorded by a binary counter.

beginning of each counting cycle, a feeder mechanism pushes the packets from the trough, one at a time and endwise, into the opening between the spindle jaws. When a packet reaches this position, an electric limit switch is actuated, which causes the spindle jaws to clamp and rotate. The packet thus rolls around the spindle and is counted by the light-beam methed. The jaws then release and the packet is cleared from the counting head by an additional revolution of the spindle. The released packet falls on a sheet-metal sorter vane, which has previously been tilted to either the correct or the reject position by an electromagnet responding to the count.

A "turntable assembly" mounted on the top of the cabinet includes the counting head with its friction band and optical assembly. The spindle jaws, together with an electromagnet that operates them, are carried in a rotating element of the turntable assembly. The optical assembly includes a lamp, condensing lens, and two small adjustable mirrors for deflecting the light beam across the path of the sheet ends as they are blown out from the end of the friction band by the air jet. The free end of the friction band is pressed against the rolled-up sheets by a compression spring and piston mechanism. The stationary table surface of the turntable assembly is inclined at the same angle as the feeder trough so that, at the end of its counting cycle, each packet of half-notes slides forward off the inclined table on to the sorting vane. The tilt of the vane, positioned by the electromagnet, causes the packet to slide to the correct or reject output chute.

Mechanical details of the pusher that holds the end of the friction band against the contour of the rolled-up sheets are rather critical. It was found that a knife-edged bearing offered the best solution to the problem of releasing only individual sheets. Another critical design feature was the position of the air-jet nozzle relative to the end of the friction band. Its opening was placed as close as possible to the contour of the surface, and set to produce an airstream tangential in direction. This proved to be the only arrangement that would give the proper swinging motion to the individual ends of the half-notes as they passed the light beam.

In the event a packet of half-notes tangles around the spindle, a limit switch ("snarl switch") adjacent to the turntable, is actuated and stops the automatic feed until the machine is cleared by hand. Other limit switches stop the machine after it runs out of packets and interlock the motion of the turntable with that of the feeder mechanism.

The sorter vane mechanism is mounted on the upper of two chassis located in the cabinet below the turntable assembly. These chassis support the magnetic relays and the electronic components. A small rotary air compressor with integral motor drive is mounted on the bottom deck of the cabinet.

The electronic counting mechanism is relatively conventional. A cathode follower applies the phototube impulses to a trigger circuit for conversion to sharp, uniform-amplitude pulses. These pulses are, in turn, applied to a binary electronic counter. The full counting capacity of this 8-stage counter is 256, whereas the desired count for a correct packet is 102 (100 half-notes, plus the wrapper sheet on each side). In ordinary production use by the Treasury, the actual numerical count resulting for each packet is not of interest, but for maintenance purposes the count is indicated by a series of neon lights located just below the output chutes.

The machine is "fail-safe" in the sense that a very large percentage of possible failures in the equipment are such as to cause all packets to be rejected. This would be quickly noticed by attendants and result in the particular machine being taken out of service. The less likely failure, in which all packets are accepted, would have the same result.

Machine Performance

The most important factor in the counting effectiveness of the machine is the condition of the money to be counted. Thus, causes of erroneous low count include extensibility of half-notes due to wrinkles; folded corners, which interfere with individual release of the sheets; folded or short sheets; and adherence of adjacent sheets due to taping of half-notes with gummy tape, cancellation punching with dull dies, or other causes. Causes of erroneous high count include interruption of the light beam by loose bits of paper, and random disturbances in the air which whip the ends of the sheets through the light beam more than once.

A study of optimum spindle speeds was made to determine the effect of varying speeds on accuracy of count. The relative advantages of low operating speeds as compared with the use of a greater number of machines to do a specific job were also considered.

The NBS electronic money counter in operation. Mrs. Patrica Hickok is observing the feeding-counting cycle of the unit. This is one of 25 units being constructed for the Treasury Department. The counters are estimated to reduce Treasury counting costs $250,000 a year.

Tentatively, the spindle speed adopted is 15 rpm, but this is subject to possible revision upward on the basis of anticipated large-scale tests that will accompany early production operation. Since the spindles are belt-driven, revision of speed is a simple matter.

Basic Counting Methods

The Bureau's first attack on the problem of counting money employed a transverse scanning method—similar to television scanning—across the clean-cut edges of piled and cut half-notes. It was immediately recognized, however, that the condition of the sheets resulted in irregularities and gaps in the lines, which made a single scan not sufficiently reliable. Subsequent studies of multiple scanning showed that the ratio of the width of the thinnest dark line (corresponding to one bank note) to the total thickness of the pile of sheets was of such magnitude as to produce light reflections requiring resolution beyond that available with the best optical system.

These difficulties led to attempts to find ways of physically separating the sheets sufficiently to permit reliable actuation of a sensing apparatus. This was accomplished by clamping one end of a packet of half-notes between the opposing faces of a spindle structure and wrapping the free ends around the spindle in a roughly circular contour. This scheme separated the ends of successive sheets by the desired regular interval.

The first sensing apparatus tested was a contact stylus of a vibration pick-up. As each bill passed over the stylus, an electrical impulse was generated and the count noted. This system is being used for counting new money, but there was some doubt as to its effectiveness with the old and wilted half-notes. Test operations, involving the counting of several thousand packets of half-notes, each containing 100 notes, resulted in a high count on about 5 percent of the packets, several times as great as permissible by the Treasury Department standards. These results led to the abandonment of the vibration pickup method in favor of the light-beam technique.

American Crystallographic Association Meets at NBS

The American Crystallographic Association held its semiannual meeting at the National Bureau of Standards on February 15 to 17, as part of the Bureau's celebration of its fiftieth anniversary. More than 200 leaders in the science of crystallography from this country and abroad attended the meeting.

Emphasis of the technical sessions was on the determination of crystal structures by X-ray diffraction. This method is one of the scientist's most powerful tools for studying the arrangement of atoms in metals, minerals, and organic compounds. It is currently being developed even further to study the enormously complicated structures of proteins—the fundamental building blocks of living organisms.

On the first day of the meeting, sessions were devoted to instrumentation for X-ray diffraction and calculations of growing crystals; the use of diffraction patterns for identifying the compounds present in unknown powdered materials; and mathematical methods for determining the structures of complex crystals. An evening lecture was given by Dr. William Cochran (University of Cambridge, Eng.) on the subject of "Accurate crystal structure analysis".

Sessions of the second day were devoted to reports on the structures of specific crystals of metals, inorganic compounds, and organic compounds. Compounds of the artificial element 43, technetium, the existence of which was recently confirmed at the NBS, were discussed by W. H. Zachariasen (Argonne National Laboratory). Eugene Staritsky and Joseph Singer (Los Alamos Scientific Laboratory) described isostructural compounds of uranium and plutonium. The crys-

THE AMERICAN CRYSTALLOGRAPHIC ASSOCIATION

extends GREETINGS to the

NATIONAL BUREAU OF STANDARDS

upon the occasion of the Fiftieth Anniversary, 1951, of the founding, and sends

CONGRATULATIONS

upon the Bureau's outstanding accomplishments in science and engineering, its research fundamental and applied in the physical sciences, its development of scientific standards of measurement, needed by science, industry, commerce, Government and the people of the United States, its pioneering studies of the properties of materials and physical constants, its splendid achievements in developments critical to the national defense, its contributions to sweeping on the operations of the Government, and presents this scroll on this 16th day of February in the year 1951 in recognition of the Fiftieth Anniversary of the National Bureau of Standards on the occasion of the annual meeting of The American Crystallographic Association held in Washington, D.C.

Scroll presented to the National Bureau of Standards by the American Crystallographic Association in honor of the Bureau's Fiftieth Anniversary.

tal structure of vitamin B_{12} was the subject of papers by Dorothy Crawfoot Hodgkin and June Broomhead (Oxford University) and by John G. White (Princeton University).

On the third day a special symposium on the chemistry and crystallography of apatites was held. Apatite (calcium phosphate) is the main inorganic material in bone and teeth and is therefore of special interest in the fields of medicine, dentistry, and bone char research. The importance of the substitution of fluorine in the structure of apatite has been highlighted by recent investigations into the use of fluorine in the reduction of dental caries.

NBS Honored With Scroll

At the ACA dinner, Dr. R. W. G. Wyckoff, president of the Association, presented a scroll to the Bureau in commemoration of its 50 years of scientific service. Accepting the scroll on behalf of the Bureau, Dr. E. U. Condon, NBS Director, stressed the Bureau's future plans for fundamental research in the physical sciences.

During a tour of the National Bureau of Standards, Association members observed the electronic computer, SEAC, at work on crystallographic calculations, the use of X-ray diffraction in metallurgical research, the synthesis of artificial mica and other crystals, the study of X-ray protection methods, the optical glass research laboratory, and the fundamental national standards of mass and length.

Glass Valves for Vacuum Control

One of the problems encountered in vacuum practice is the ready and accurate control of gas flow into or through a system. It is important that the device used for such control should not be a source of contamination and should not liberate unwanted gases. The standard stop-cock normally used for this purpose has been found unsatisfactory because its grease seal does not permit application of the high heats necessary for degassing. This results in undesirable contamination, while the grease itself is a source of trouble.

To overcome these and other difficulties, as well as to provide an improved seal, R. Forman of the Bureau's electron tube laboratory has developed a glass-seal type of valve that operates at pressures of the order of 10^{-6} mm of mercury. The new valve depends on the expansion of glass or metal when heated. This elongation characteristic is utilized to break a glass seal that separates the vacuum system from another of higher pressure. When the source of heat is removed, contraction of the glass reseals the system.

The valve has the appearance of a conventional water condenser with but one side-arm. It is made of 7052 hard glass, chosen because its coefficient of expansion matches that of a Kovar sleeve inserted into the outer jacket. The center tube is sealed at one end and terminates at the other end in a graded seal, permitting incorporation of the unit into any Pyrex system requiring this type of control.

One of the properties of two optically polished surfaces is the enhancement of the intermolecular force that acts to hold the two surfaces in contact. Before incorporation into the system, the concentric tubes of the glass valve are carefully cut with a glass saw, and the surfaces are optically polished to a high degree of flatness. The ends are then placed in contact once again and are held in this position by the molecular

This glass valve was developed for use in high-vacuum or low-pressure applications. The insert in the outer tube is a Kovar sleeve, which rapidly conducts the heat radiating from an induction heater to the glass. Expansion and contraction of the outer tube opens and closes an optically polished cut in the inner tube, resulting in a valve action.

force. A forepump is connected to the inner tube, and the unit is pumped to some convenient value of vacuum. With the external pressure and the intermolecular forces holding the cut sections together, the outer jacket is glass-welded with a sharp flame. At this stage, there are two forces on the inner tube: the molecular adhesion and the external air pressure. During the cooling process, contraction adds another force. The total effect of these forces makes the seal vacuum-tight.

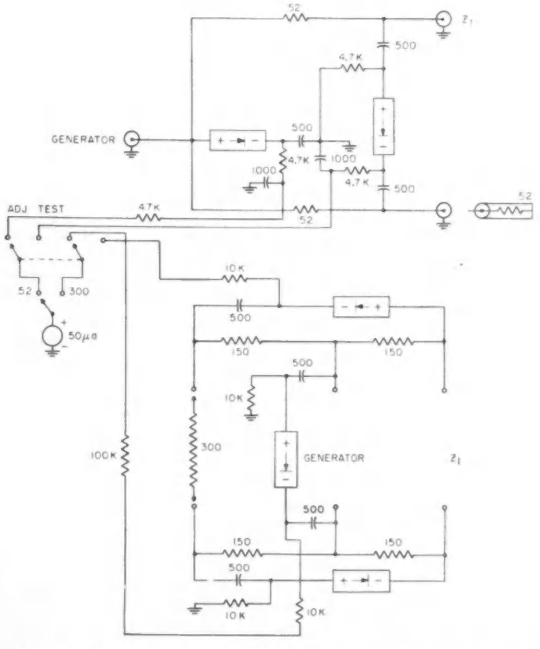
Under standard operating conditions, the inner tube is at the desired vacuum, and the space between the inner and outer tubes is at approximately the same pressure as the gas to be admitted to the system. The Kovar sleeve is heated to a temperature of about 200°C by an induction heater, and heat flows from the Kovar into adjacent parts of the outer glass jacket. The over-all expansion of the outer tube exerts a force that opens the cut in the inner tube. When the desired quantity of gas has entered the system, the induction heater is turned off, and the resulting contraction of the outer jacket once again seals the system.

In operations requiring the admission of special gases to the system, a gas bottle is sealed to the sidearm. Several variations of this particular design and use of the glass valve are possible. Instead of the Kovar sleeve inserted into the outer jacket, the unit can be made entirely of Pyrex, and the heat necessary to cause expansion supplied by an external heater.

Tests have shown that this valve makes possible a continuously variable control of the rate at which gas can be admitted to an evacuated system. Complete data are not yet available for establishing a lower limit for use as an adjustable leak. However, initial measurements indicate that leakage through the valve into a 1-liter volume will raise the gas pressure by as little as several tenths of a micron in 1 hour. Another application for this device would be as a calibrated leak for a mass spectrometer leak detector.

A VHF Match Meter

A simple and extremely compact match meter, capable of indicating the magnitude of the reflection coefficient of a transmission-line impedance, has been developed by Peter G. Sulzer of the National Bureau of Standards. The instrument, employing the Wheatstone-bridge principle in the 10- to 250-megacycle frequency range, may be applied to problems of antenna matching or the adjustment of receiver and transmitter coupling circuits. Particular application is in television equipment, where reflections must be minimized and where compact equipment is required.



Circuit diagram of the VHF match meter. This unit uses crystal diodes, type 1N34, in its voltage reading circuits. The upper portion of the diagram is the 50-ohm unbalanced bridge, the lower section is the 300-ohm balanced bridge circuit. The 50-microampere ammeter is switched into the two circuits to read input and null voltages developed in the circuit.

The match meter, a small self-enclosed unit, is placed between a low-powered r-f source and the antenna, transmission line, or circuit to be checked. Two simple measurements suffice to obtain the magnitude of the reflection coefficient. These measurements may be made with respect to two impedances, 52 ohms (unbalanced) and 300 ohms (balanced), over the frequency range of 10 to 250 megacycles.

The three basic components of the instrument are a 52-ohm bridge, a 300-ohm bridge, and a voltmeter with its associated switches. The voltmeter, which consists of a 0–50 direct-current microammeter and crystal diodes, is used to read both the bridge input voltage and the bridge null voltage. During measurement the direct-current meter itself is switched from input to null points, the crystal diodes remaining in their respective positions at all times.

Experience has shown that match meters are subject to various errors, particularly at VHF. These errors usually result from residual reactances in the bridge arms, or from voltmeter imperfections such as low impedance or calibration inaccuracy. However, the symmetrical construction of the match meter makes it possible to obtain a null over the entire frequency range when the bridge is terminated in the matching impedance. Thus, when the unknown impedance is adjusted for a match, changes tending to produce a null will be in the proper direction.

As a precaution against stray pickup, a shielded generator should be used with the match meter. This is particularly important in making measurements of balanced, unshielded transmission lines. In addition, a balanced generator must be used with the balanced

bridge to avoid longitudinal currents in the line connecting the generator to the instrument.

Comparison measurements made on devices having known reflection coefficients have indicated a maximum error of 0.1 over the entire frequency range from 10 to 250 megacycles.

For further technical details, see VHF match meter, *by Peter G. Sulzer, Television Engineering, July (1950).*

Precise Determination of Moisture in Rubber

An improved apparatus for precise determination of moisture in rubber has been developed by Max Tryon of the NBS rubber laboratory. Possessing significant advantages over devices now available commercially, the new apparatus should provide a rapid, simple means for accurate determination of water in leathers, textiles, oils, dried foods, and other organic materials. At the same time it offers a convenient tool for basic research in these fields.

The Bureau's apparatus is used in the method that involves the formation of a minimum-boiling azeotrope (constant-boiling mixture) of an immiscible organic liquid with the water present in the material, distillation of the azeotrope, and separation of the water as a separate phase for volumetric determination. Decomposition of the sample is prevented by the relatively low temperature at which the distillation takes place.

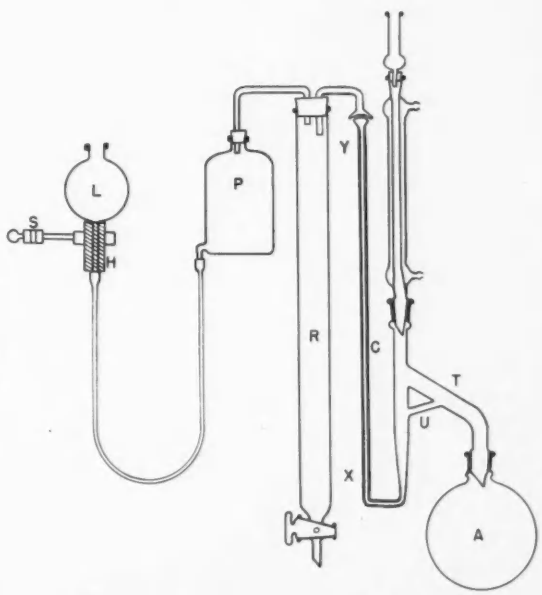
While several types of apparatus have been used previously to separate out and measure moisture in this way, most of these devices have disadvantages that limit their convenience and accuracy. For example, the water usually tends to adhere to parts of the apparatus rather than to collect in the graduated portion, where its volume is to be measured. Other problems have been the difficulty in reading accurately the volume of water collected and poor separation of the water from the organic liquid. In connection with a broad program at the Bureau on the chemical and physical properties of Government synthetic rubbers, it became necessary to determine the small amounts of water present in certain types of synthetic rubber that could not be analyzed by the usual procedures. The Bureau therefore developed the improved apparatus, which the Office of Rubber Reserve has now accepted as a referee method for determining moisture in all types of synthetic rubber.

This apparatus consists essentially of a distillation flask in which the sample is heated, a reflex condenser with a drip tip, a trap for collecting the water that separates out in the condenser, a capillary tube for measuring the distilled water, and a waste receiver with a drain stopcock at the bottom. The waste receiver is connected to a bottle of water, which is, in turn, connected by rubber tubing to a leveling bulb.

The sample is placed in the distilling flash along with sufficient dry toluene to cover it completely. Additional toluene is placed in the trap, and the flask is heated to distill the toluene-water azeotrope at a rapid rate. Droplets of distilled water appear in the condenser and settle to the bottom of the trap, the condensed toluene forming a separate liquid phase above the water. Distillation is stopped when no more water droplets appear in the distillate dropping into the trap. After the water in the trap has returned to room temperature, the leveling bulb is lowered until this water is drawn up into the calibrated capillary tube, where its volume can be measured. Lowering the leveling bulb still further flushes all of the water and toluene in the trap into the waste receiver, and the apparatus is ready for another determination. This procedure allows another sample to be run almost immediately.

The apparatus is cleaned periodically by pouring toluene into the trap through the condenser and lowering the leveling bulb to draw the solvent through the capillary into the bottom of the waste receiver and out through the stopcock in the receiver. To reduce the time spent in cleaning the distillation flask, disposable paper linings, dried in quantity by a distillation procedure similar to that applied to the sample, have been used at the Bureau.

By collecting the water in a large-volume traps, sharp separation of water and toluene, not always possible with narrow water-collecting tubes, is achieved. This



Improved apparatus developed by NBS for determination of moisture in rubber. The rubber sample, together with some dry toluene, is heated slowly in the distillation flask (*A*) until no more water droplets appear in the distillate dropping into the left side of the trap (*T*) from the condenser above. After all the water has collected in the bottom of the trap as a separate layer below the toluene, the leveling bulb (*L*) is lowered until this water is drawn into the capillary tube (*C*).

feature, combined with the use of the graduated capillary for actual measurement of the water volume, results in greater over-all precision.

Increased precision and accuracy have also been obtained by the use of a water-repellent coating of silicone polymer on all the inner surfaces of the apparatus to prevent water droplets from adhering to the glass. This makes it possible to collect all the water in the graduated capillary for measurement. Use of the coating also reverses the usual water-glass meniscus.

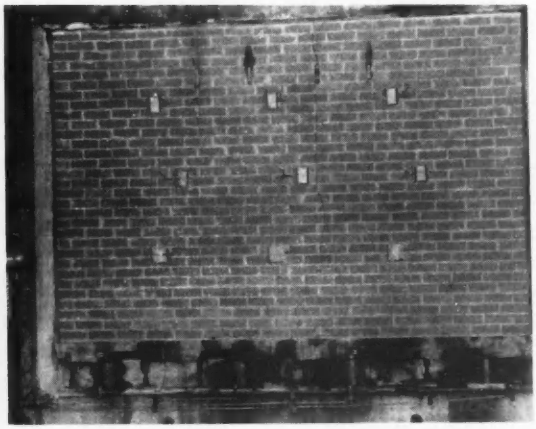
The results with this apparatus at the Bureau on samples containing about 1 percent of water have been of the same order of accuracy as those obtained with the Karl Fischer technique. The method has been evaluated in several experiments, designed for statistical analysis, in which the effects of a number of possible variables were studied. It was found that the procedure when applied to rubber is characterized by a standard deviation of 0.023 percent. For accurate work, allowance must be made for incomplete recovery of all the water in the sample. In the case of rubber, the recovery is about 96 percent.

For further technical details, see An improved apparatus for determining moisture in rubber by distillation with toluene, *by Max Tryon, J. Research NBS* **45**, *362 (1950) RP2146.*

Fire Endurance of Hollow-Brick Walls

Fire-resistance ratings have been established for hollow-brick walls of 8-inch thickness through a series of fire-endurance and hose-stream tests at the National Bureau of Standards. The tests were carried out in the Bureau's panel furnace, which is one of the few furnaces of this type in the United States. The ratings average about 2 hours less than those of 8-inch solid-brick walls, but are nevertheless considered adequate for most situations.

Although hollow-brick construction is not widely used, it has found favor in some localities. One advantage is the insulation afforded at ordinary temperatures by the cellular construction. Another advantage is economy in materials and construction. The hollow bricks were 7½ by 11½ by 3½ inches in size, about 5 times the volume of ordinary bricks. The two interior cells represented approximately 58 percent of the volume of the unit. The web between the cells was 1½ inches thick and the shell, 1¾ inches thick. Closure units of half-size brick were also employed in building the standard test wall.



Blackening of the wall surface marks the position of loosely framed wood joists in the hollow-brick wall without plaster. Hydraulic jacks simulate building loads by applying pressure to the bottom of the wall. Thermocouples measure the temperature at nine locations.

The fire-endurance test consists essentially of applying a fire of known and controlled intensity to one side of the wall and at the same time observing what takes place on the other side. This is accomplished by building a wall of standard size into a movable steel frame. The wall and frame are then placed in position against the open face of a large, gas-fired furnace. They thus become in effect one side of the combustion chamber of the furnace. Overhead tracks and trolleys facilitate moving the frames into and away from the furnace. Where a wall or partition is designed to support building loads (known as "load-bearing" or "bearing" walls), a pressure that simulates the load is applied during the test by means of hydraulic jacks. The complete procedure is described in *Standard methods of fire test of building construction and materials* of the American Standards Association (ASA No. 2.1–1942).

Temperatures in the furnace are controlled so that they conform to a standard time-temperature curve, as follows:

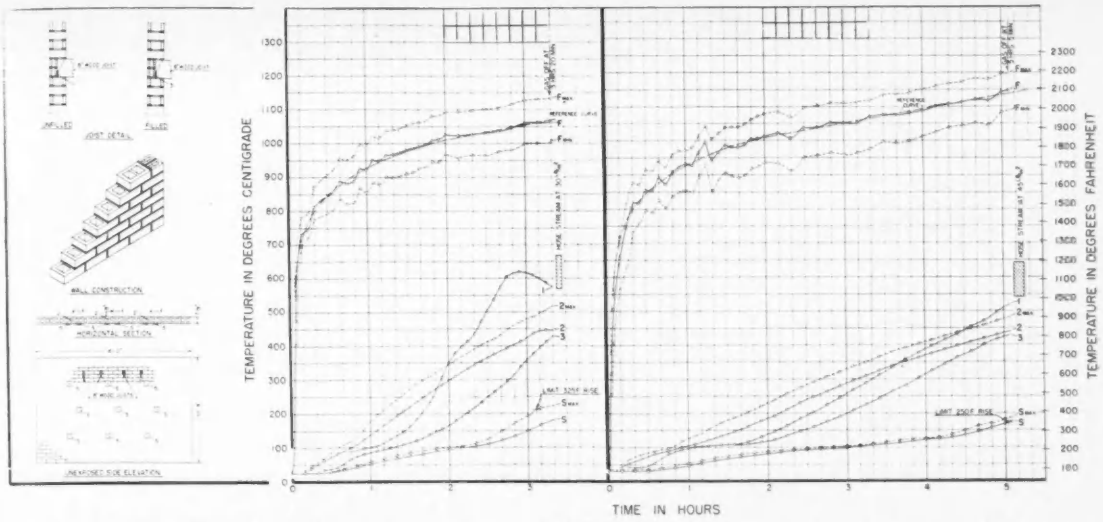
Time		Temperature
hr	*min*	° *F*
—	5	1,000
—	10	1,300
—	30	1,550
1	—	1,700
2	—	1,850
(a)		(a)
8	—	2,300

[a] Increasing at a rate of 75 degrees per hour to reach 2,300° F in 8 hours.

Temperatures are also measured at several locations on the face of the wall that is not exposed to the fire. Observations are made of buckling or bulging, and of breaks in the wall that would allow fire or hot gases to pass through.

Finally, to establish a fire-resistance rating, the wall must withstand the impact of a hose stream on the side that has been exposed to the fire, without passage of water through the wall. The hose stream is applied at the end of a predetermined fire exposure or at the termination of the fire-endurance test.

The exposure is continued until one of the criteria of failure is reached. These are: failure under the



Complete analytical data from fire-endurance tests on hollowbrick walls are summarized in graphs: (left) without plaster; (right) both sides covered with sanded gypsum plaster. The increased fire resistance of the plastered walls may be attributed to the added thickness, the insulating value of the plaster, and the heat absorbed in calcining it. Thermocouple designations correspond to those in the construction drawings (left). Solid lines represent average temperatures as measured by all thermocouples similarly located; broken lines, individual observations at any one thermocouple.

applied load; passage through the wall of flame or gases hot enough to ignite cotton waste; an average temperature (at 5 or more specified locations) on the outer surface of the wall greater than 250 degrees F above the starting temperature; or a temperature of 325 degrees F above the starting temperature at any one point on the outer surface. When the hose stream is to be turned on the specimen, the frame and wall are pulled rapidly away from the furnace and into a clear space by means of the track and trolley. A stream of water is then directed toward the wall from the fire hose. Water pressure is carefully controlled and the hose nozzle is kept at a measured distance from the wall.

Two of the hollow-brick walls were constructed. They were representative of a construction practice in which part of the building load is supported through combustible members framed into one side of the wall. Stubs of 8-inch yellow-pine floor joists were therefore framed 4 inches into each wall on the side that would be away from the fire. Some joists in each wall were loosely framed (that is, not embedded); others were closely embedded on three sides in noncombustible material. A limiting temperature rise of 250 degrees F at any point on the combustible member (wood joist) in the former case, and 325 degrees F in the latter, determines the protection afforded to the member. It is also a criterion of failure of the wall. One wall was finished on both sides with sanded gypsum plaster to a thickness of $\frac{5}{8}$ inch. The second wall was without plaster. Thus the two walls effectively provided six separate fire-resistance ratings.

Potomac River building sand was used with Portland cement and hydrated lime for the mortar of both walls, and with sisal-fibered gypsum for the plaster. The mortar mix, as well as the load applied during the test, was that specified in the *American standard building code requirements for masonry*. (NBS Miscellaneous Publication M174, see note).

The walls, which were 16 feet long and 10 feet 4 inches high, were constructed upon steel loading beams within the steel test frames. To avoid the effect of edge restraint on deformations, they were built so that at each end a 1-inch space remained between the walls and the vertical members of the frames. Before they were tested, the walls were seasoned in the laboratory for $2\frac{1}{2}$ months during the summer.

1901 NBS 1951

Semicentennial Meeting Calendar

—May—

3– 4	Bone Char Conference II
7	Society of American Military Engineers
10–12	Acoustical Society of America
14–15	Horological Institute of America
16	Industrial Research Institute
16–18	Society for Experimental Stress Analysis
17	Electrochemical Society (Baltimore-Washington Section)
22–25	Thirty-sixth National Conference on Weights and Measures

A load of 70 pounds per square inch of gross bearing area was applied continuously to the wall throughout the fire-endurance and hose-stream tests by means of hydraulic jacks acting on the loading beams. Temperatures in the furnace and at locations in the wall cells, on the ends of the framed-in joists, and on the unexposed surfaces of the walls were determined with thermocouples. Vertical wires from which to measure the deflection of the walls during the test were hung opposite the center line of the wall and the quarter points of its length. Standard fire hose and play pipe were used for the hose-stream test.

The fire-resistance ratings of the six different types of construction embodied in the two walls are shown in the accompanying table. Both walls withstood the application of the hose stream without passage of water to the opposite face. The plaster on the fire-exposed side of the wall was washed off by the hose stream, but this is in no sense considered a failure of the wall. Minor deflections under load occurred in both walls during the tests; cracking of the brick shells and webs so that some fire-exposed face shells could be removed was not sufficient to reduce unduly the load-bearing strength of a wall or seriously impair its watertightness. The greater fire resistance shown by the wall with both sides plastered can be attributed to the increased thickness of the wall and the insulating value of the plaster and the heat absorbed in calcining it.

These tests on hollow-brick walls were made in cooperation with the Southern Brick and Tile Association.

Fire-resistance ratings of 8-inch walls of hollow brick

Type of construction			Ratings
			Hours
Without plaster	Framed-in combustible members.	Unembedded	1½
		Embedded in noncombustible materials.	2
	Without framed-in combustible members.		[a] 3
Finished on both sides with plaster	Framed-in combustible members.	Unembedded	2½
		Fully embedded in mortar.	3
	Without framed-in combustible members.		[a] 5

[a] Determined by the rise in temperature on the unexposed side.

Note: Fire-resistance ratings of many other types of building construction are given in Fire-resistance classifications of building constructions (BMS92), *available only from the Government Printing Office, Washington 25, D. C., at 30 cents a copy. Miscellaneous Publication M174 is also available from the same source for 15 cents.*

Publications of the National Bureau of Standards

Periodicals

Journal of Research of the National Bureau of Standards, volume **46** number 3, March 1951 (RP2188 to RP2194, incl.).

Technical News Bulletin, volume **35,** number 3, March 1951. 10 cents.

CRPL–D79. Basic Radio Propagation Predictions for June 1951. Three months in advance. Issued March 1951. 10 cents.

Research Papers

Reprints from Journal of Research, volume 46, number 2, February 1951

RP2178. Temperature variation of mass spectra of hydrocarbons. Robert M. Reese, Vernon H. Dibeler, and Fred L. Mohler. 10 cents.

RP2179. Absorption and emission spectra of promethium. William F. Meggers, Bourdon F. Scribner, and William R. Bozman. 10 cents.

RP2180. A statistical solution of a problem arising in the sampling of leather. John Mandel and Charles W. Mann. 10 cents.

RP2181. Heats of combustion, formation, and isomerization of ten C_4 hydrocarbons. Edward J. Prosen, Frances W. Maron, and Frederick D. Rossini. 10 cents.

RP2182. Effect of a metal mast and guy wires on the performance of the 600-ohm multiple-wire delta antenna. Harold N. Cones. 10 cents.

RP2183. Heat of solution of zinc oxide in 2 N hydrochloric acid. Richard B. Peppler and Edwin S. Newman. 5 cents.

RP2184. Bounds for characteristic roots of matrices II. Olga Taussky. 5 cents.

RP2185. Microhardness tester for metals at elevated temperatures. Abner Brenner. 10 cents.

RP2186. Mechanisms for the mutarotation and hydrolysis of the glycosylamines and the mutarotation of the sugars. Horace S. Isbell and Harriet L. Frush. 10 cents.

RP2187. Infrared studies of association in eleven alcohols. Francis A. Smith and E. Carroll Creitz. 15 cents.

Building Materials and Structures Reports

BMS121. Investigation of failures of white-coat plaster. Lansing S. Wells, Walter F. Clarke, Edwin S. Newman, and Dana L. Bishop. 25 cents.

Publications in Other Journals

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